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Natural Hazard Preparedness And Mitigation in India

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NATURAL HAZARD PREPAREDNESS AND MITIGATION IN INDIA

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ABSTRACT

Indian sub-continent is highly vulnerable to geological and hydro-meteorological hazards. Occurrences of hazard events like earthquakes, cyclones, floods, landslides have, more than often turned into disasters of varying severity with devastating impact on development process destroying human lives, property, livelihoods and social fabric.

Efficient management of disasters, rather than mere response to their occurrence, has in recent decades, received an increasing attention of the national planners leading to the formulation of Disaster Management Act in 2005 by Government of India. The national policy enshrined in the Act marked a paradigm shift from the erstwhile post-disaster relief-centric approach to pro-active approach based on prevention, mitigation and preparedness.

The new policy catapulted initiatives in the areas of hazard evaluation and quantification, risk assessment of built infrastructure capacity building of concerned stakeholders, structural audit and upgradation of existing unsafe buildings, post disaster damage and need assessment, updating the disaster specific codes, amending the building byelaws, land-use zoning practices of urban local bodies.

The Paper summarizes the practices, institutional mechanisms and regulatory framework those emerged from the above initiatives and which are getting gradually established as accepted practices at national, state, district and local levels.

INTRODUCTION

India due to its locational and geo-climatic conditions as well as its high socio-economic vulnerability, is one of the most disaster prone countries in the world. Having been under constant threat of the natural hazards, which more than often turn into disasters, the country has developed its own practices and strategies for preparedness and mitigation to cope with such disasters. Given both the population explosion and increased need of development, the exposure, the scale and impact of natural hazards is increasing. During past two decades, there has been an alarming increase in the number of disasters, like earthquakes, cyclones, floods, landslides, tsunami, windstorms. Frequently hit be variety of natural disasters, both the government and people have been engaged in a continuing pursuit, for a holistic approach, encompassing all facets of disaster management. However, till early nineties the understanding and approach to management of disasters remained myopic and mostly relief-centric, like in most developing countries. With the rising global concern for mounting losses of human lives and erosion in the gains of development programmes due to frequent occurrences, the Government of India has also actively addressed the issues flagged by international initiatives like International Decade of Natural Disaster Reduction (IDNDR), Yokohoma Strategy, Habitat Agenda Hygo-Framework for Action 2005-2012 and its national policy gradually headed towards a paradigm shift in the approach to disaster management. Erstwhile relief-centric approach is being gradually replaced by more of pro-active approaches based on prevention, preparedness, mitigation and quick response which were acknowledged as an integral part of effective disaster management strategy.

Recognizing the fast emerging concerns worldwide, the first organized effort at the highest level in the country was made in 1999. A High Powered Committee (HPC) was constituted by the Government of India with a mandate to review the then existing arrangements for preparedness and mitigation of natural disasters and recommend measures to bring about institutional reforms in the field and planning of disaster

management. After having nation wide consultations with various stakeholders, like professionals, practitioners, experts, academic and R&D institutions, Community based organizations, NGOs and governments at different levels, wide-ranging recommendations were made by the committee. Recommendations made by the HPC for evolving institutional structures at National, State, District and Local levels as well as several severe natural hazard events hitting the country, in one part or the other, during the period 1991to 2004, led to the national resolve for bringing in the paradigm shift in the policy. Thus the Disaster Management Act was brought out by the Government of India, in 2005, and the subject of natural disaster management was for the first time, integrated with the Development Process as reflected in the Tenth Five Year Plan 2002-2007. The Ministry of Home Affairs, Govt. of India replacing the Ministry of Agriculture was made the Nodal Ministry / Agency for disaster management in the country.

NATIONAL DISASTER MANAGEMENT STRUCTURE

The institutional structure for disaster management in India is in a state of transition. For implementation of the Disaster Management Act – 2005 the National Disaster Management Authority (NDMA) chaired by Prime Minister has been set up at national level. The NDMA has the mandate to lay down the policies, plans and guidelines for State governments to prepare their respective Disaster Management Plans. The State Disaster Management Authorities are being set up at State (Provincial) and UT levels (SDMA) under the chairmanship of respective Chief Ministers, and lately formation of District Disaster Management Authorities (DDMAs) at district level is also being formalized. Some State Governments have taken lead over others and the structure is already in place upto district level. In 16 states SDMAs and DDMAs are already functioning. Figure-1 gives the Disaster Management Structure in India. The stakeholders at different levels have freedom to interact with SDMAs, DDMAs while the structure also draws involvement of concerned Ministries, Government Departments and administrative bodies functioning at Central and State levels as well as Community Based Organizations (CBOs) NGOs and Civil Society.

The Disaster Management Act, keeping in line with the 73rd and 74th Amendments to the Constitution entrust and empowers the Local Bodies both in Urban and Rural areas as important tiers of governance to play specific roles for disaster mitigation, preparedness and response activities.

National Plan for Disaster Management

The National Policy of Disaster Management (NPDM) approved in October 2009, with its vision of "a Safe and Disaster Resilient India" aims at developing a holistic, pro-active multi-disaster oriented and technology driven strategy. The policy covers all aspects of disaster management, like institutional structures, techno legal and financial arrangements, pro-active action areas to reduce vulnerabilities, management and reduction of disaster risk, capacity development, knowledge management, research, education, training and S&T interventions needed for disaster prevention, mitigation, preparedness and response. Flowing from the action areas under the policy new institutional mechanisms are being put in place and existing ones strengthened.

Following paragraphs mention some of the initiatives taken under the new policy and which are already changing the ground situation in the areas of hazard assessment, quantification, risk assessment, vulnerability reduction promoting mitigation measures and strengthening preparedness capacities at different levels.

Sub-Area Plans

One important activity currently taking place is preparation of "National Plan of Disaster Management". The plan has following three components. The three sub-committees have been constituted and these are so structured that relevant stakeholders are encouraged to contribute in the development of plans in the respective areas.

- National Response Plan
- National Mitigation Plan and
- National Capacity Building Plan

National Mitigation Plan

As the efforts for disaster mitigation are spread over in different socio-economic sectors which contribute to the planning and execution of development projects in the country, the nodal officers to coordinate preparation of the mitigation plans have been designated for different disasters. For example, mitigation plans for Earthquake, Floods, Landslide and Avalanche are being prepared under the designated Ministries by involving representatives from sectoral ministries as given in Table 1. The Plans are being formulated taking into account both Structural and Non-structural Mitigation measures.

NDMA has already formulated guidelines (focusing on action areas with fixed time target) for managing risks from various hazards, after a through consultation process involving multiple stakeholders both from public and private sectors, NGOs, academic and S&T institutions, corporate sector and community based organisations. The details of guidelines are available at the website : www.ndma.gov.in. The guidelines for risk management with respect to Earthquakes, Cyclones, Landslides and Snow Avalanches, Floods, Tsunami have already been issued and widely circulated.

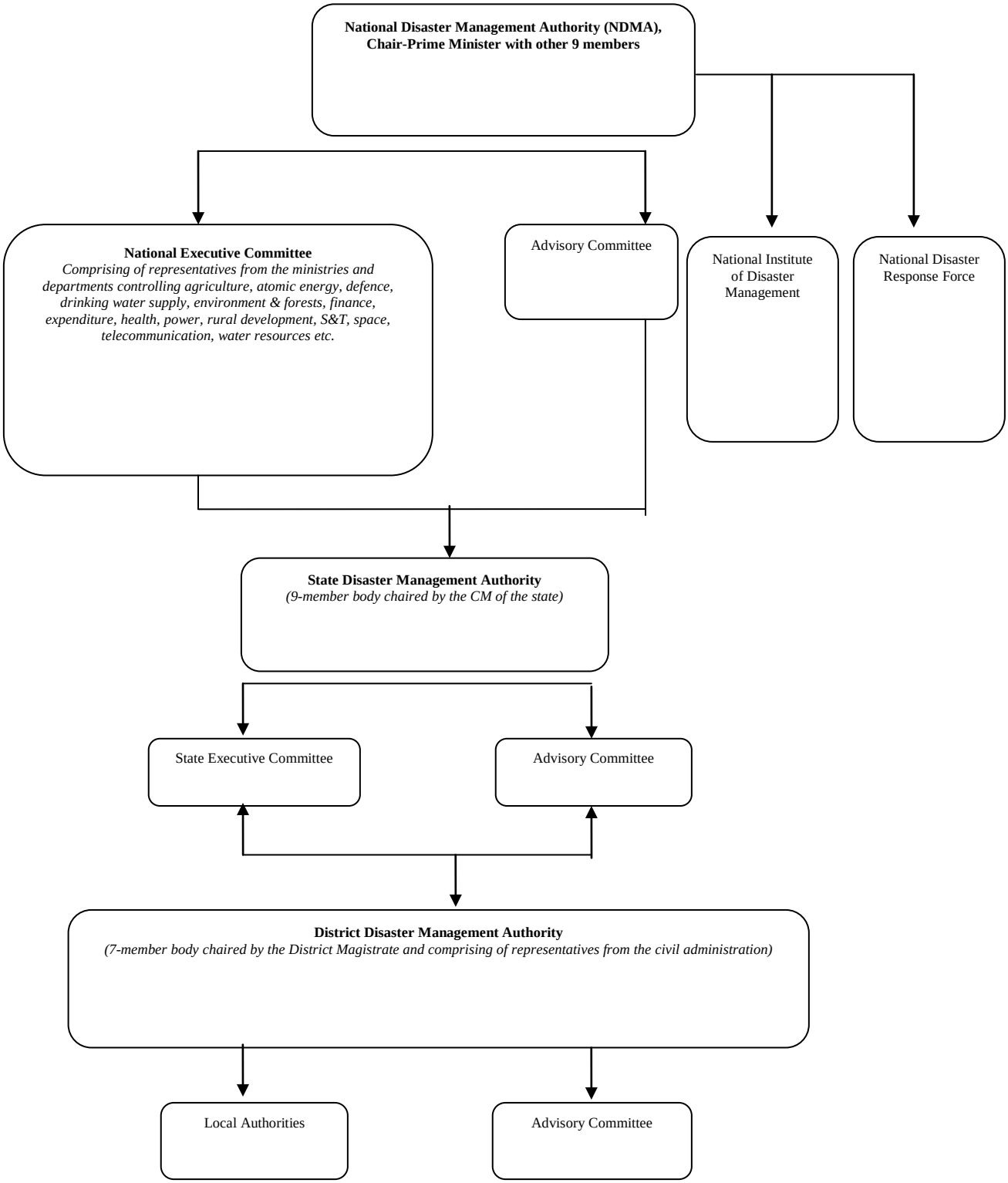


Fig. 1. Disaster Management Structure in India

EARTHQUAKE RISK MITIGATION

Though NDMA has been engaged in preparing a National Earthquake Risk Mitigation Project but it is yet to take off as consultative process with stakeholders is going on for past two years. However, India being a signatory of Yokohoma strategy (1994) under IDNDR, number of initiatives were taken and efforts made have already shown results in the following important areas leading to strengthening of both structural and non-structural mitigation strategies. Following are some of main areas where mitigation activities have been widely undertaken in the country.

Mainstreaming Earthquake Mitigation

The initiatives taken include,

a. Strengthening of Seismological instrumentation network
b. Hazard mapping and vulnerability assessment of buildings
c. Promoting earthquake resistant construction
d. Seismic strengthening and retrofitting
e. Strengthening regulatory framework for mandating compliance to Codes and Standards, by amending building by laws and land use zoning practices.
f. Capacity development – education, training, research and development, capacity building and documentation of lessons learnt.

2.

Table 1. Nodal Ministries for mitigation of different disasters

Disaster	Nodal Ministries	Members drawn from
• Earthquakes	Earth sciences	Ministries of S&T, Space Urban Development, Human Resource Development, Health & Family Welfare, Panchayati Raj, Youth Affairs, Women & Child Development, Telecommunications, Information & Broadcasting.
• Floods	Ministry of Water Resources	Space and Telecommunication
• Landslides	Ministry of Mines (Geo-logical Survey of India)	Road Transport & Highways, Shipping.
• Avalanches	Ministry of Defence	Road Transport & Highways, Shipping.

Seismological Instrumentation Network

The Department of Science and Technology (DST) Government of India in mid nineties coordinated a World Bank assisted project under which seismological observatories in the peninsular shield were strengthened. Under this project 20 the then existing observatories of IMD, were strengthened (10 CSN stations, & 10 stand alone Broad Band Digital Stations) and 10 new observatories were built. The DST had also launched a nationally coordinated project on the study of seismicity and seismotectonic in the Himalayan region involving several R&D organizations. The strong motion data collection programme has been expanded and a number of tall buildings and other structures were instrumented to study their behaviour during future earthquakes including Soil-structure interaction effects. Figure-2 shows the upgraded seismological network in the peninsular shield region (1999).

Hazard Mapping and Vulnerability Assessment of Buildings

With the initiative of Building Materials & Technology Promotion Council (BMTPC),Ministry of Urban Development a Vulnerability Atlas of India was prepared (1994-1997), in which the earthquake, cyclone and flood hazard maps for every state and Union Territory of India were prepared to a scale of 1:2.5 million. Besides state wise hazard maps, district wise (for all districts in the State) risk table of different

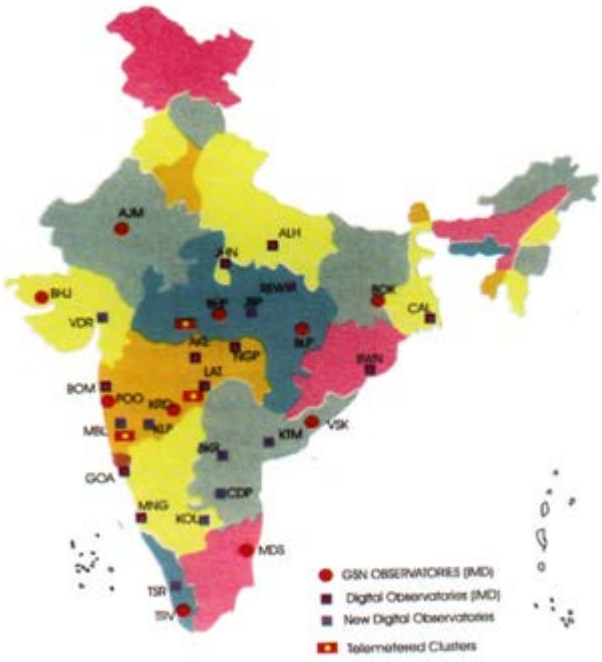


Fig. 2. Upgraded Seismological Instrumentation Network in the Peninsular Shield Region

[Source : Earthquake Research in India, Earth System Science Division, Department of Science and Technology, Govt. of India, 1999]

categories (based on roof wall combination) of existing housing in the district have been given. After 2001, the new Census of Housing had come showing changing trends of typology, three new states were carved out from existing states, 90 new districts were formed and Seismic Zoning Map of India was revised by the Bureau of Indian Standards in 2002. Thus the need was felt to revise and update the hazard maps and vulnerability assessment of buildings according to 2002 census. In view of these developments, the Atlas was revised during 2004-2007 and the second version was released in 2007. The state hazard maps shows the boundaries of each administrative district clearly marked with hazard intensity. This helps in identifying specific land area of the district prone to hazard risk. Earthquake hazard maps (Figure 3), have been based on Seismo-Zoning map of India given in IS 1893:2002 and seismo-tectonic features are marked as per Seismo-Tectonic Atlas brought out by Geological Survey of India. Epicentres and years of occurrence of earthquakes (> 5.0 intensity) have been shown as per Indian Meteorological Department (IMD) Catalogue of Earthquakes.

Wind and Cyclone Hazard Maps (Figure 4) are based on wind speed maps given in IS 875 (Part III) 1987. Alongwith design wind speed, the number of cyclones which had crossed each latitude of the Sea Coast in the past are also marked on these hazard maps.

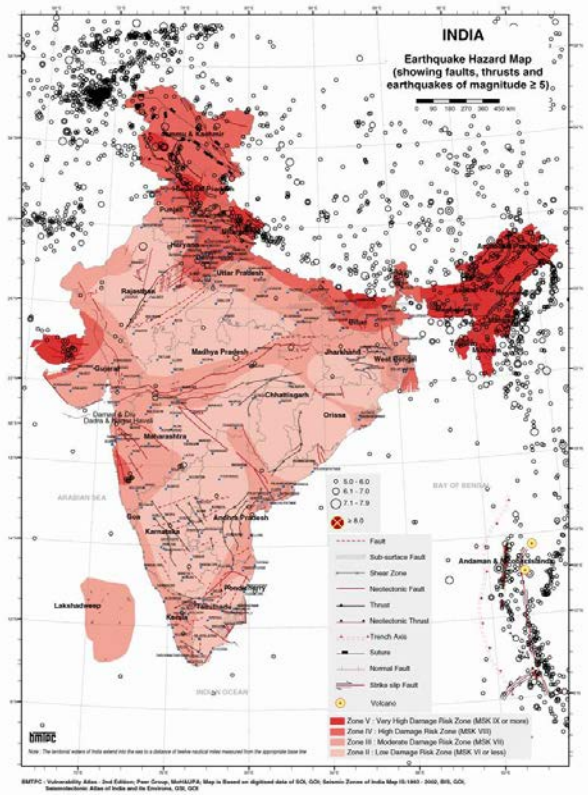


Fig. 3. Earthquake Hazard Map of India

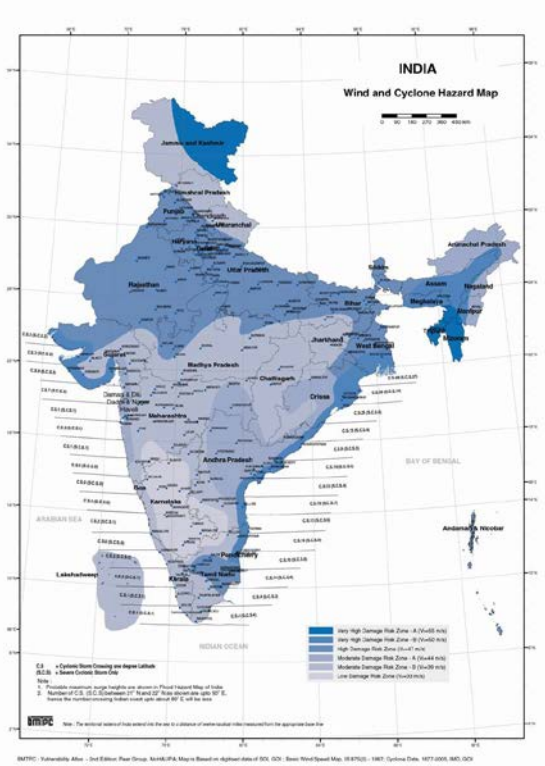


Fig. 4. Wind/Cyclone Hazard Map of India

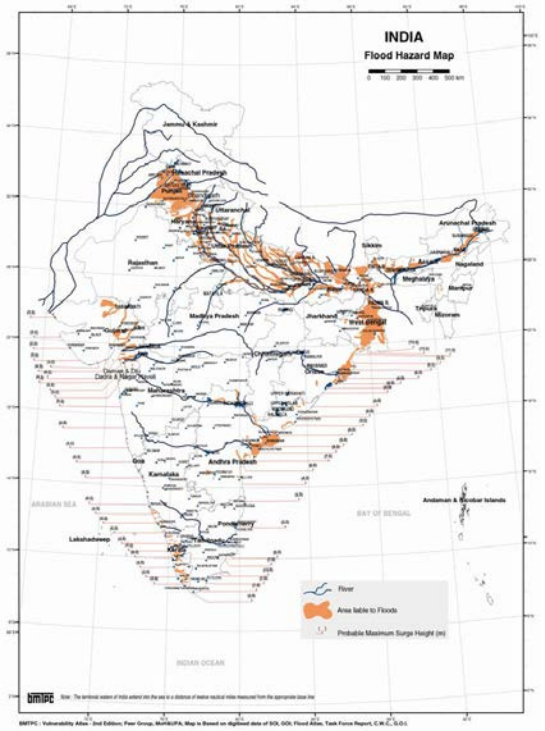


Fig. 5. Flood Hazard Map of India

Flood Hazard Maps (Figure 5) are based on the revised Flood Atlas of India prepared by Central Water Commission, Govt. of India. Other low lying areas outside river flood planning (which also get flooded during heavy rains due to choked drainage path) could not be plotted due to lack of data.

Some of the special features in the Revised Atlas (2007) are; (i) Digitisation of all data sets in hazard maps including the boundaries of states / UTs and districts as per Survey of India maps as well as the boundaries of various hazard zones, thus improving their accuracy. (ii) Vulnerability and Risk tables of Housing Data in each district is based on wall types and roof types as per 2001 Census of India (Figure 6), (iii) Inclusion of a note on Tsunami wave effects in the coastal regions and (iv) inclusion of Landslide Hazard Zones (Figure 7).

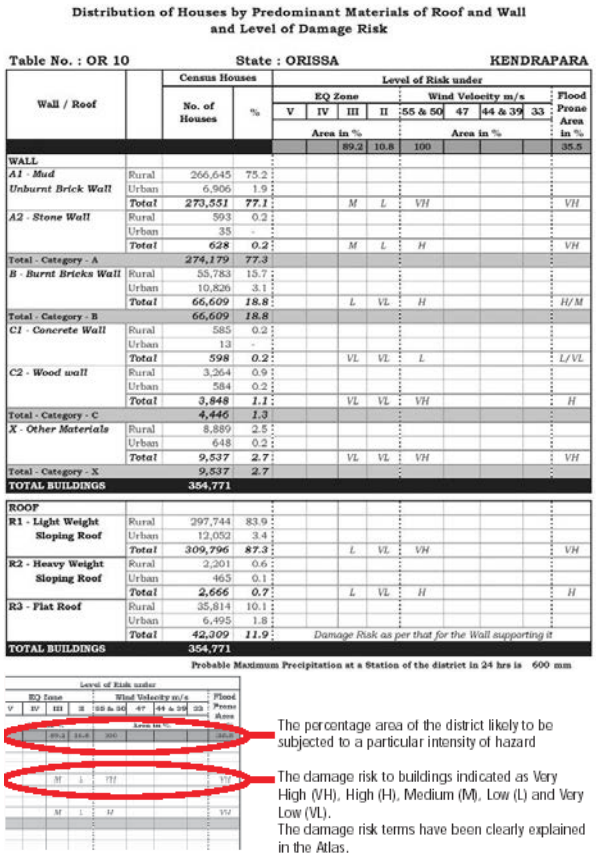
Promoting Earthquake Resistant Construction

Realising that most casualties during earthquakes are caused by collapse of buildings and other structures (both engineered and non-engineered) and also that nearly 80 percent of building stock in India belong to non-engineered category, it was strongly felt by planners that structural mitigation measures are the key to make a significant impact towards earthquake safety of the built environment. The policy on Risk Management lays great emphasis on promoting, through advocacy and mandatory regulations, earthquake-resistant construction for all new buildings (particularly built with public funding) and improving structural capacity of existing ones (by suitable retrofitting methods) to cope with the forces generated during earthquakes.

Following important initiatives have been taken in the country by concerned authorities, organizations and institutions,

i) Disaster related Standardization: India has been on the leading edge as far as standardization for managing earthquake risk in built environment is concerned. Research, education and training in earthquake engineering were started at the then University of Roorkee (now Indian Institute of Technology – IIT). The academic inputs from School of Earthquake Engineering of Roorkee helped the then Indian Standards Institution (ISI now BIS – Bureau of Indian Standards) in developing Indian Standards and Codes of practice on earthquake safe design and construction in early sixties, later updated and revised from time to time.

The earthquake activity in different parts of India is not of the same severity. Hence the country had earlier been classified into five zones I to V, the forces for which structures were to be designed at any site are varied according to the severity of probable earthquake



Distribution of Houses by Predominant Materials of Roof and Wall and Level of Damage Risk

Table No. : OR 10 — **State : ORISSA** — **KENDRAPARA**

Wall / Roof		Census Houses: No. of Houses	Census Houses: %	Level of Risk under: EQ Zone V	EQ Zone IV	EQ Zone III	EQ Zone II	Wind Velocity m/s: 55 & 50	Wind Velocity m/s: 47	Wind Velocity m/s: 44 & 39	Wind Velocity m/s: 33	Flood Prone Area in %
				Area in %				Area in %				
						89.2	10.8	100				35.5
WALL												
A1 - Mud	Rural	266,645	75.2									
Unburnt Brick Wall	Urban	6,906	1.9									
	Total	*273,551*	*77.1*			*M*	*L*	*VH*				*VH*
A2 - Stone Wall	Rural	593	0.2									
	Urban	35	-									
	Total	*628*	*0.2*			*M*	*L*	*H*				*VH*
Total - Category - A		*274,179*	*77.3*									
B - Burnt Bricks Wall	Rural	55,783	15.7									
	Urban	10,826	3.1									
	Total	*66,609*	*18.8*			*L*	*VL*	*H*				*H/M*
Total - Category - B		*66,609*	*18.8*									
C1 - Concrete Wall	Rural	585	0.2									
	Urban	13	-									
	Total	*598*	*0.2*			*VL*	*VL*	*L*				*L/VL*
C2 - Wood wall	Rural	3,264	0.9									
	Urban	584	0.2									
	Total	*3,848*	*1.1*			*VL*	*VL*	*VH*				*H*
Total - Category - C		*4,446*	*1.3*									
X - Other Materials	Rural	8,889	2.5									
	Urban	648	0.2									
	Total	*9,537*	*2.7*			*VL*	*VL*	*VH*				*VH*
Total - Category - X		*9,537*	*2.7*									
TOTAL BUILDINGS		354,771										
ROOF												
R1 - Light Weight Sloping Roof	Rural	297,744	83.9									
	Urban	12,052	3.4									
	Total	*309,796*	*87.3*			*L*	*VL*	*VH*				*VH*
R2 - Heavy Weight Sloping Roof	Rural	2,201	0.6									
	Urban	465	0.1									
	Total	*2,666*	*0.7*			*L*	*VL*	*H*				*H*
R3 - Flat Roof	Rural	35,814	10.1									
	Urban	6,495	1.8									
	Total	*42,309*	*11.9*	*Damage Risk as per that for the Wall supporting it*								
TOTAL BUILDINGS		354,771										

Probable Maximum Precipitation at a Station of the district in 24 hrs is 600 mm

The percentage area of the district likely to be subjected to a particular intensity of hazard

The damage risk to buildings indicated as Very High (VH), High (H), Medium (M), Low (L) and Very Low (VL).
The damage risk terms have been clearly explained in the Atlas.

Fig. 6. Vulnerability and Risk Table of Kendrapara District of Orissa

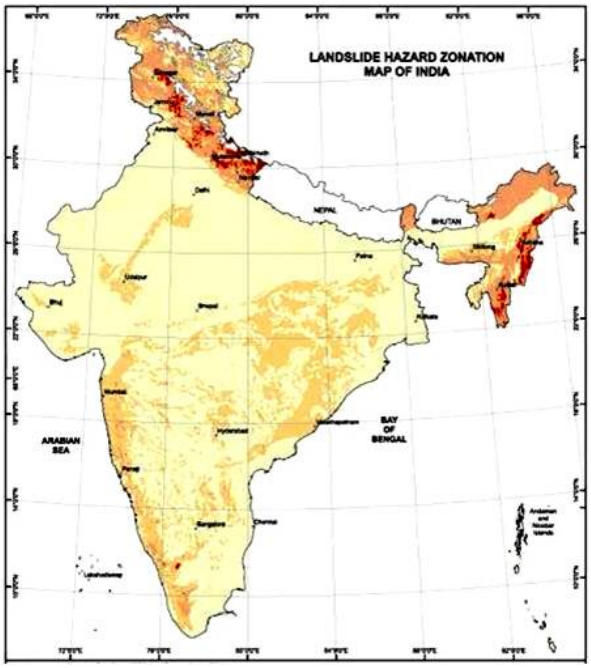


Fig. 7. Landslide Hazard Zonation map of India

intensities (IS : 1893 – 1984 zoning map). In the fifth revision of IS: 1893 in 2002, the Seismic Zoning Map has also been revised to eliminate Zone I by merging into Seismic Zone II. The area covered by Zone IV and V remains unchanged, Zone II has been enlarged in peninsular India and Zone II covers earlier Zones I and II with minor additional modifications. For list of relevant standards for earthquake safe design and construction please refer BIS site www.bis.org.in.

ii) Several Guidelines and handbooks have been brought out on Earthquake Safe design and Construction by Central Public Works Department, Government of India, academic institutions, Indian Buildings Congress. Building Materials and Technology Promotion Council (BMTPC) have published brochures / guidelines / Dos & Dont's for non-engineered construction based on traditional practices. Some of these are based on "the lessons learnt" from their post-disaster Damage Assessment Studies in the regions badly affected by few highly devastating earthquakes like Chamoli : 1991; Latur : 1993; Jabalpur : 1997; Bhuj : 2001; Kashmir Valley: 2005. For guiding safe construction activities during post earthquake repair and reconstruction programme some of these guidelines have been brought out in vernacular languages.

iii) The Government of India and the UNDP have for past over ten years, supported a long term Disaster Risk Management programme across 176 multi hazard prone districts in 17 states. Though the focus of this programme is on capacity building of different stakeholders but one important sub-component focuses on creating awareness about how to build disaster safe houses by integrating modern knowledge of disaster resistant construction with prevailing traditional local practices. Some of the Non-governmental organization (NGOs) who have been actively involved with execution of the GOI-UNDP program are; National Centre for Peoples' Action in Disaster Preparedness (NCPDP); Ahemdabad Study Action Group (ASAG); SEEDS India; UNNATTI, TARU, they all have made significant contribution towards spreading awareness and Hands-on-Training in earthquake safe construction practices through wide-spread action on the ground they covered during last two decades. A large number of Trainers' Guides and Manuals (particularly NCPDP) have been brought out by these organizations and their activities have been documented by national and international agencies like BMTPC, UNDP, UNESCO.

iv) In the North-east region of India there are 8 States and the whole region lies in Seismic Zone IV and V. BMTPC during 2001-2006 promoted Bamboo based Construction of 10 Demonstration Buildings Figure 8 (like School, health centre, Tourist hut house etc.) in three states of the region. Bamboo is a locally grown forest / plantation produce item on which local people have been historically enjoying rights for use in building construction and other applications. Earthquake and wind resistant design of buildings using chemically treated local bamboos were developed and demonstrated in these constructions. Earlier Bamboo mat corrugated roofing sheets were developed by BMTPC in 1998-99 and a commercial plant for manufacturing these sheets was set up near Guwahati (Capital of Assam). The same sheets have been utilized for Construction of these demonstration buildings in the three states.

Fig. 8. Bamboo based Earthquake and Wind resistant buildings in Mizoram [BMTPC Annual Report]

Seismic Strengthening and Retrofitting

India has a very large stock of non-engineered buildings both in rural and urban areas. This building stock mainly consists of housing, schools community buildings, commercial and service buildings like workshops, shops, small scale industrial units etc. Since nearly 60 percent geographical area of the Country lies in seismic zones II to V, and country has over 241 multi hazard districts, and nearly 120 million buildings lie in seismic zones III, IV and V. Majority of these buildings are potentially vulnerable to collapse in the event of high intensity earthquake. Besides this stock which continue to grow year after year, new constructions being added with modern materials (concrete, steel, aluminum etc.) and designed by engineers and architects, mostly built in unorganized sector have been found non-compliant of earthquake codes of practice. Collapse of multistoryed buildings during Bhuj earthquake, in city of Ahemdabad (300 miles away from epicenter) exposed clearly that even the engineered (as claimed by owners and professionals) buildings are also vulnerable to potentially destructive natural events in future.

As it is not practically feasible or financially affordable (for owners) to carryout seismic strengthening or retrofitting to reduce their vulnerability, the National Guidelines on Management of Earthquakes, recommend urgency only for critical lifeline structures and high priority buildings. Every state government is expected to select their buildings in the category of critical lifeline or high priority ones in the light of characteristics of their existing built environment. There are three Indian Standards viz. IS: 13828 – 1993, IS: 13827-1993 and IS: 18935-1993 on Improving Earthquake Resistance of Low strength Masonry Buildings, of Earthen Buildings and "Repair and Seismic Strengthening of Buildings" respectively. Besides the availability of these codes, organizations like BMTPC, SERC Chennai, Earthquake Engineering Departments at IITs Roorkee and Kanpur have also developed suitable cost efficient and simple retrofitting techniques for seismic strengthening and upgradation of different types of non-engineered and semi-engineered buildings.

NCPDP is an Non-Governmental Organisation with first hand experience of working at the grass roots, mainly in the areas of training of masons / artisans and retrofitting of damaged traditional buildings in the after math of divesting hazard event. They have implemented a number of retrofitting cum training programme sin various part of the country.

BMTPC Initiatives for Promoting Simple Retrofitting Methods

i) For structural safety audit, simple methods of residual strength assessment of existing buildings like visual screening, non-destructive techniques have been developed. BMTPC have also supported technically and financially preparation of Guides and Videos Training Manuals for training local masons, artisans, contactors, engineers in the methods of retrofitting of both types of buildings either constructed as non-engineered with traditional methods or with engineered buildings but with scarce regard to codal provisions leading to inadequate resistance to earthquake impact / forces.

Assessment of residual strength of buildings which did not suffer collapse but were shaken in the settlements effected by earthquake, was carried out in Latur region (Maharashtra) where a devastating earthquake of 6.3 magnitude occurred in 30th Sept 1993 resulting in huge loss of life and property. Recognizing that a large number of buildings, though did not collapse, but had suffered shaking and became more vulnerable to any future earthquake, a retrofitting /strengthening progamme was undertaken. The typology of buildings was nearly same (with thick wall in random stone masonry and wooden roofs loaded with 2 to 3 ft thick mud for

Field Shock-Table Programme for Confidence Building in Earthquake Resistant Retrofitting Technology for Load Bearing Masonry Structures.

During sever earthquake event, maximum damage has been observed in masonry walls of different kinds of vernacular buildings. The severity of impact has eroded peoples' confidence in their own building methods and materials, which they have used for ages. The fall out of this has been that people started demolishing their undamaged houses and constructing with different materials and technologies that are not local. Such a shift was noted for the first time during Latur earthquake of 1993. There was another section of households who continued to occupy their vulnerable houses due to their ignorance about vulnerability or about retrofitting options available for vulnerability reduction.

To build peoples' confidence in quake resistant building technologies including the retrofitting of existing vernacular buildings, the NCPDP (Ahmedabad) took the initiative to put Shock-Table Programme with following objectives:

- Build peoples' confidence in quake resistant building technologies including retrofitting of existing buildings
- To enhance understanding of the performance of simple structures with and without quake-resisting features under the impact of an earthquake
- To learn the ways of reducing vulnerability of crores of vernacular structures in the country.

Shock Table Programs consist of comparative testing of two half scale models that allows people to explicitly see the difference in performance of both structures simultaneously, one that is commonly built and the other with disaster resistant construction or duly retrofitted. Such programs were carried out in the aftermath of earthquakes in Latur and Kutchch, and were found to be effective. Programme in Latur, Maharashtra was conducted in association with BMTPC and in Kutchch, Gujarat with Nirma University Institute of Technology.

heat insulation) as of those houses which collapsed or badly damaged in the most effected settlements. A illustrative manual for repair and reconstruction work was prepared and was distributed in the region. In order to build confidence of local people in the recommended retrofitting technique a Field Shock-Table Test was carried out in the rural area. Two half scale model houses (one retrofitted and other unretrofitted) were tested with very satisfying results. The series of test carried out in the presence of hundreds of local villagers really created confidence in the BMTPC recommended technique for retrofitting.

ii) Following are some other retrofitting projects undertaken by BMTPC in collaboration with State Disaster Management Authorities and NCPDP (Ahemdabad).

- Retrofitting of partially damaged houses with earthen walls and bamboo-thatch or wood, clay tile roofs in earthquake hit region of Jabalpur (Madhya Pradesh) after earthquake of 6.0 magnitude occurred on 22 May 1997.

- Retrofitting of a few public buildings damaged during Bhuj Earthquake of 26th Jan 2001. These included Police Station at Rapar, **(**Figure 9, masonry building construction a colonial style in 1890 and was considered a heritage building) and Primary School building at Ahemadabad.

  Retrofitting of Sub-divisional Hospital in Kupwara, Jammu & Kashmir after the earthquake of 7.6 (Richter Scale) hit the region on 8th October 2005 (Figure 10)**.** This hospital was one of the lifeline buildings in this administrative division, and had suffered cracking in the front as well as rear wings. After assessment of its expected structural performance the building was found to have several deficiencies for safety against earthquake forces (if one was to occur in future). Besides retrofitting, the local people and masons were sensitized through distribution of illustrated brochures printed in Urdu (local language).

- Retrofitting has been carried out in 5 school buildings (including 2 multi-storied) of Municipal Corporation of Delhi (MCD) located in different urban zones. During the retrofitting work, an awareness cum training programme was conducted for nearly 250 MCD engineers with a view to train them in seismic strengthening techniques.

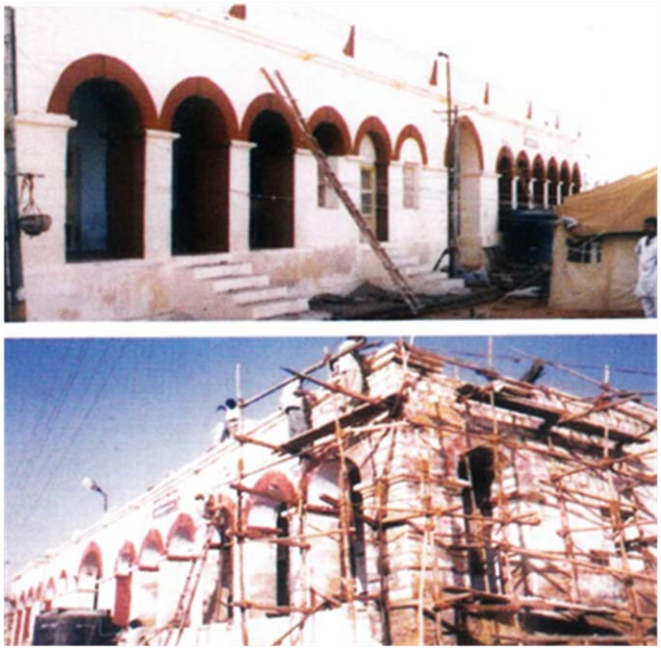


Fig. 9. Retrofitting of Police Station Building at Rapar (Gujarat) [Source : BMTPC Annual Report 2002- 2003]

Fig. 10. Retrofitted Sub-Divisional Hospital Building at Kupwara, Jammu & Kashmir [Source : BMTPC]

STRENGTHENING REGULATORY FRAMEWORK

Implementation of Techno-Legal Regime to Promote Earthquake Mitigation

High vulnerability of built elements in urban and rural settlements in India is mainly the result of a huge non-engineered stock of housing and the buildings built without compliance to standards, codes and regulatory requirements for safety, even ignoring the mandatory ones. Yet another factor which compounds the problem further is continuing migration of large number of families migrating from rural to urban settlements thereby resulting in the growth of slums, squatter settlements which in many cases are located on unsafe land and built with very inadequate construction techniques using fragile materials.

Situation that prevails in most of urban settlements and huge non-engineered housing stock both in large, medium, small urban and rural settlements, underscored the need to address the issues of quality and safety in construction, design standards and codes, site selection, control of landuse,

permissible densities and role of all those who are involved in mitigation of risk due to natural hazards. Currently, construction projects in India are expected to comply with several technical provisions that are specified in various Techno-legal Acts and Regulations being implemented by Urban Local Bodies (ULBs) or local Urban Development Authorities. While some provisions of these Acts and Regulations stipulate for town planning norms (viz. land use zoning, road width, siting of other urban amenities, set-back of buildings), a few other provisions speak about building bylaws/regulations defining standardized norms for various components of the building. Many of the provisions of building bylaws (building regulations) are intended to ensure that all constructions meet certain safety norms and do not adversely affect the safety of their occupants or the people at large. However, experiences from recent natural disasters clearly illustrate that these provisions are not fully complied with, resulting in avoidable damage to the built environment and the consequent adverse impacts on community.

The Governments at Central and State Level have been concerned and making required efforts to establish Techno-Legal mechanisms to ensure that all stakeholders adopt and adhere to acceptable safety benchmarks in design and construction of new buildings, maintenance and strengthening of existing ones and post disaster reconstruction and rehabilitation schemes.

The Ministry of Home Affairs GOI, appointed multi-disciplinary Expert Group (with Author as a Member) to study the existing Municipal Byelaw's and other documents meant to control and regulate growth and development in urban areas etc. and propose essential amendments in buildings Byelaws. Land-use zoning regulations, development control rules, and in Town and Country Planning Legislations with the aim to ensure that all these regulatory instruments can enforce safety measures in planning, design, construction, siting of different types of buildings and can adequately regulate developments in urban centres.

In the areas prone to flooding, realizing the need for large scale survey maps of vulnerable and flood prone areas, to enable proper flood plain zoning, the CWC had initiated, in 1978 a programme for surveying areas prone to floods through Survey of India (SOI) to assist state governments. Maps to Scale 1:15,000 were prepared and sent to respective state governments (of Bihar, Assam, Jammu & Kashmir). However, progress is very slow on the part of State Governments (except in few) to adopt these maps in their practice.

The NDMA had asked the State governments / State Disaster Management Authorities to enact and enforce appropriate laws for implementing flood plain zoning regulations. Yet another important recommendation made by NDMA to State Governments / SDMAs was to restrict unplanned growth so that construction of structures obstructing natural drainage resulting in increased flood hazard is not allowed.

Amendment in Development Control Regulations: This part deals with the development control rules and general building requirements to ensure health and safety of the public. The regulations for Land Use Zoning in Hazard Prone Areas are expected to be taken into consideration while formulating the Development Plans and special Area Plans under the Town Planning and Urban Development Act.

Every person who gives notice under relevant section of the Act shall furnish all information in forms and format prescribed as may be amended from time to time by the Competent Authority. The following particulars and documents are to be submitted along with the application.

The forms, plans, sections and descriptions to be furnished under these Development Control Regulations shall all be signed by each of the following persons:

- A person making application for development permission under relevant section of the Act.
- A person who has prepared the plans and sections with descriptions who may be Architect on Record or Engineer on Record.
- A person who is responsible for the structural design of the construction i.e. a Structural Engineer on Record.
- A Construction Engineer on Record who is to look after the day-today supervision of the construction.
- A Developer/ Promoter/Owner

A person who is engaged either to prepare plan or to prepare a structural design and structural report or to supervise the building shall give an undertaking in the prescribed format.

Registration of Technical Professionals: Under the proposed Techno-Legal Regime, all Urban Local Bodies (ULBs) are expected to register architects, engineers (structural and construction), town planners, quality audit firms, project consultants, contractors, etc. The project owners will appoint their own 'professionals on record', out of those who are registered with ULB. Thus it will be mandatory for the 'professionals on record' to give the above mentioned undertaking that they will follows codes and safety aspects in the construction.

No land shall be used as a site for the construction of building:

i) If the site is found to be liable to liquefaction by the Competent Authority under the earthquake intensity of the area, except where appropriate protection measures are taken.
ii) If the Competent Authority finds that the proposed development falls in the area liable to storm surge during cyclone, except where protection measures are adopted to prevent storm surge damage.

iii) In hilly terrain, the site plan should include location of land slide prone areas, if any, on or near the site, detected during reconnaissance. The Authority in such case shall cause to ensure that the site is away from such land slide prone areas.
iv) The site plan on a sloping site may also include proposals for diversion of the natural flow of water coming from uphill side of the building away from the foundation.

Grant or Refusal of the Permission for Development: On receipt of the application for Development Permission, the Competent Authority after making such inquiry and clearance from such an expert whenever considered necessary for the safety of building, as it thinks fit may communicate its decisions granting with or without conditions including condition of submission of detailed working drawing / structural drawing along with soil investigation report before the commencement of the work or refusing permission to the applicant as per the provisions of the Act.

Capacity Building of Officials and Professionals of Local Authorities: Urban Local Bodies, numbering nearly 5100 in the country, are the largest owners of life-line buildings, structures and infrastructure networks. Thus it will be necessary for them to arrange training programmes for their technical personnel particularly those associated with the scrutiny and approval of plans submitted for construction projects and inspection.

Emphasizing the need for capacity development four-pronged action plan is recommended. It includes, (i) Periodic awareness meets at regional level for Mayors/Corporators focusing on reporting of quantifiable progress achieved by each ULB, lying in seismic regions, (ii) Regular training programmes for town planners, architects, engineers and plan approving officials for regulating seismic safety in the new projects and in methods of carrying structural safety audit of existing built stock, (iii) ULBs must collaborate with academic institutions of excellence and eminent professionals having practical experience from large construction entities to provide training to their staff and practicing local engineers and architects in structural safety auditing methods and practice of forensic engineering, and (iv) municipal officials/engineers are to be relevantly trained in modifications to existing buildings, including seismic strengthening projects, will also require approval from the municipal officer. Again, the structural design calculations and drawings will be scrutinized for common buildings and peer reviewed for special and important structures.

Model Development Control and Building Regulations including Safety Provisions in Rural Areas: Considering that nearly 750 million people live in rural settlements in about 177 million housing units constructed with large variety of materials and construction techniques most of which are highly vulnerable to destruction under the impact of one or the other natural hazards (viz, earthquakes, cyclones, floods and landslides) the Ministry of Home Affairs, under their GOI-UNDP Disaster Risk Management Programme prepared the Model Development Control and Building Regulations for health and safety of the people including safety in construction against natural hazards in the form of simplified Guidelines for construction with mud walls, stone and brick masonry. These suggested guidelines have been recommended to be followed by Panchayats but necessary directions need to be issued by the governments of respective states and UTs.

Techno –Financial Regime

The National Policy on Disaster Management envisages that a Techno-Financial Regime would be worked out to strengthen the sharing and transfer of disaster risk in the built environment. Some financial practices such as disaster risk insurance, micro-finance and micro-insurance, warranty of newly constructed houses and structures and linking safe construction with bank loans and funded by Government of India is under active consideration for adoption by the Government.

With financial supports from banks and other lending institutions, there is a steady growth trend in construction sector by real estate companies and individuals. There are three critical aspects in the current practice of the banks offering financial assistance to construction projects that do not guarantee disaster-resistance in the structure proposed to be built or being built. These are:

i) At the time an application is made to a bank seeking financial loan to construct any building or structure, it is not necessary that it is designed in full. The architect and/or structural engineer provide a certificate that they will undertake the design appropriately at later stage.
ii) Even before the construction of the building or structure is started, the design of the whole structure is not always furnished either to the municipal corporation due to the lack of such definitive provisions in prevailing local building bye-laws or to the banks funding the construction.
iii) The technical professionals (structural engineer and/or architect) assisting the banks recommend that loan may be given to a project, without necessarily seeing the design of the complete structure, and sometimes simply based on their perception of the credentials of the architect and structural engineer of the project. All of these are loopholes of the practice that augur against ensuring safety of the constructions.

Advisories issued by RBI: Reserve Bank of India (RBI) has issued several proactive advisories to banks for verifying disaster safety and planning issues while granting loans for any building construction. In this regard, RBI's circular of 1st March 2006 asking banks to ensure prior permission from

government /local governments/ other statutory authorities for the project, wherever required, while giving loans to real estate sector is to be noted. Similarly, again emphasizing importance to safety of buildings especially against natural disasters, RBI has issued advisory to all banks on 12 June 2006 for adherence of National Building Code, 2005 while approving loans for any building construction.

Techno-Financial Regime for Urban and Rural Areas: Against the above backdrop, a techno-financial regime of banks and other lending institutions extending loans for building construction in both urban and rural areas is expected to take care in regulating all construction as disaster resilient construction in the country. The loan delivery mechanism needs to be considered as an opportunity for financial institutions to introduce appropriate disaster resistance in constructions in building sector. The financial institutions are also equally keen to ensure that the physical assets created through their lending schemes remain safe during at least repayment period of 15-30 years.

Depending on the construction project and the proneness of its location to any or many of the hazards, under the new regime the financial institutions would insist on the condition to ensure incorporation of disaster resistant features in the construction before the loan is sanctioned/disbursed. Therefore, role of the Financial Institutions and banks is critical in creating such a regime. The regime would be applicable to both new constructions as well as additions or alterations to full or part of existing constructions. The regime would be applicable to all constructions, including (a) entire range of housing constructions, from those built for self occupation to those provided by builders and developers to individuals, and (b) other bank-financed constructions, such as lifelines, infrastructure, and commercial complexes and buildings.

CAPACITY BUILDING OF PROFESSIONALS IN EARTHQUAKE RISK MANAGEMENT

Effective disaster management require duly qualified and relevantly trained manpower to deal with complex situations for reducing impact of disasters on human life and buildings and infrastructure. It has been increasingly realized that there are not many technical professionals (engineers / architects) practicing in private sector who have knowledge of seismic safe designing and construction, structural safety audits, seismic strengthening and retrofitting of existing unsafe buildings. India has a huge stock of non-engineered buildings. Even for public sector engineers and those working in local bodies (municipalities / corporations development authorities) need was recognized for training in seismic safe design and construction as per provisions in national Codes and Standards.

Against the above backdrop the country has adopted a strategic approach for capacity development based on active and enthusiastic involvement of all stakeholders. Differentiating the capacity development from capacity building, the adopted strategy focuses on capacity building of all those who handle one or the other activity relating to disaster preparedness, mitigation, prevention, reconstruction, while capacity development is viewed as a long-term continuing process that encompasses; Education, Research, Awareness creation, Sensitization and Capacity building through tailor-made training programmes addressed to the need of enhancing capabilities of professionals like architects, engineers, design groups, construction consultants, municipal engineers and all those dealing with construction projects.

Following are some of the major programmes on capacity building of technical professionals which were undertaken by IITs (Roorkee, Kanpur) and SERC, Chennai:

1. National Programme for Capacity Building of Engineers in Earthquake Risk Management (NPCBEERM) and another (initiated in 2004-05) (Funding support Rs. 123.6 million)
2. National Programme for Capacity Building of Architects in Earthquake Risk Management (NPCBAERM) (Initiated in 2004-05) (Funding support Rs. 45 million)

The above two programmes had two components of

(a) Training in Earthquake Engineering to the faculty of selected Engineering Colleges from States / UTS.
(b) Training of Engineers from State Public Works Departments and Local Bodies.

Output : 10,000 Engineers Trained, 420 faculty members from engineering colleges trained as Trainers. Training was conducted by National Resource Institutions / IITs / IIS / CSIR Laboratories. After 2007-08 the programme is being implemented by National Institute of Disaster Management (NIDM) functioning as an apex institution under the Ministry of Home Affairs, Govt. of India.

Institutional Framework for Capacity Building

National Disaster Management Authority has entrusted the National Institute of Disaster Management (NIDM) functions as the apex national organization. NIDM established in 2003, conduct training programmes in following formats:

i) Face to face training programmes are conducted both in-campus and off-campus. The off-campus programmes are conducted in State Capitals. The participants of all programmes include, middle level administrators / engineers / architects / town planners working in government departments. Nearly 100 programmes focusing on diversified themes relating to disaster management are conducted every year and nearly 2000 participants attend these programmes.

ii) Recently NIDM in collaboration with World Bank Institute Washington has started conducting on-line (web-based) training programmes.

iii) Besides the above, NDMA extends financial and policy support to Industrial Training Institutes (ITIs), Polytechniques, Universities, NIITs, Schools of Architecture in States to strengthen their teachers training QIP programs on various subjects related to disaster management but particularly focusing on enhancing capabilities in planning designing and implementation of building construction projects.

BMTPC, like in several areas, have been playing a leading role in area of capacity building through, training programmes of practicing engineers, architects, municipal engineers (responsible for project design approval) supervisors / masons / artisans in different parts of the country. Some of the important training programmes conducted are:

i) After January 2001 earthquake in Gujarat, BMTPC partnered with Gujarat State Disaster Management Authority (GSDMA) and conducted several awareness creation programs for engineers and training of masons. Nearly 5500 masons were trained in use of disaster resistant construction techniques. This programme was coupled with construction of 477 model houses in 477 villages. These were constructed to demonstrate earthquake resistant features for houses. Currently all these buildings are serving as a Disaster Preparedness Centres for local building artisans and general public.

ii) Training of 500 municipal engineers in different states have been conducted for proper implementation of Techno-Legal Regime. The BMTPC officials along with a Consultant conducted such two / three days programs on awareness creation and Indian Standards to be used as basis of design in the projects which are submitted to Urban Local Bodies for approval.

iii) Training of masons in disaster resistant techniques and repair and retrofitting of damaged houses was conducted jointly by BMTPC; HUDCO, NCPDP in Latur, BMTPC-NCPDP in Chamoli, Jabalpur, Gujarat during post disaster phase of reconstruction.

iv) BMTPC in collaboration with IIT Kanpur had brought out (in 2002-2005) a set of '24 Earthquake Tips'. These tips are targeted for awareness particularly amongst architects. Several Schools of Architecture have utilized them in last 4 years for teaching of "Seismic Architecture" a subject which has introduced in course syllabi of B.Arch. For wider circulation, these Tips were also published in various building and construction related journals, like New Building Materials & Construction Review, Journal of Builders Association of India. These Tips became very popular nationally and internationally as links were provided by popular websites: www.lcjonline.com/eqtips/IITK-BMTPC, www.nicee.org, www.mceer.buffalo.edu/ infoscience/ennos/issues and many others.

v) The Author with another expert has developed a series of tailor-made programme (with targeted topics of relevance) for private practicing engineers, architects and for those working in Public Sector Undertakings (PSUs). The topics have been selected to suit the professionals who are working either in earthquake prone areas or cyclone or landslide prone areas. The proposal has been sent to NIDM, who would be conducting these training programmes during the coming year. The suggested programmes cover (i) Design, Construction and Supervision of new Structures, (ii) Seismic/Safety Evaluation and Strengthening of Existing Buildings, Behaviour of Buildings (with different typologies) during Hazard Events and Aspects of Repair, Restoration and Retrofitting.

Awareness and Sensitization

The task of creating awareness amongst the target groups/stakeholders who contribute significantly towards earthquake preparedness and mitigation continue to be most challenging. The measures so far taken in the country includes activities pertaining to the following:

i) To improve understanding of hazard status and threats amongst people – the State-wise Vulnerability Atlases indicating hazard intensities in each district have been prepared and are available on 'net'. This includes percentage area of the district likely to be subjected to a particular intensity of hazard for guidance of those who live in comparatively safe areas of the district.

ii) In order to prepare general public on how to organize themselves before, during and after earthquake – a series of small illustrative brochures have been developed and widely distributed and are published in national and regional papers intermittently. Recently, a system of Mock drills has been introduced (to test the earthquake response capacity) by several State Governments in the capital cities which have received a great response of people from different walks of life.

iii) Technical professional groups are being equipped by engineering colleges/State administrative institutes about developing upgrading and maintaining disaster resistant built environment. Many city governments (like Delhi, Mumbai, Ahmebadad, Guwahati, Patna,

etc.) do organize one/two events every year for local professionals on disaster safety aspects.

Sensitization : NDMA has started organizing one day meets for elected representatives at different levels to sensitize them about the hazard status in their constituencies and threats to the settlements and action that awaits their attention. Similarly, State Governments and SDMAs are using media and organizing such meets for Mayors, Corporators and Municipal Commissioners, with a view to sensitize them, about possible activities they can undertake to reduce disaster risk in the development and maintenance of built environment in their respective areas. NDMA has recently introduced a good programme in a TV channel.

CONCLUDING REMARKS

No doubt, India has been actively pursuing a path leading to paradigm shift in disaster management from a relief-centric approach in the past to current holistic one, but challenge lies in striving towards higher levels of understanding, preparedness, mitigation efforts and response mechanisms. Towards strengthening the Disaster Risk Reduction (DRR) effort, the Government of India recently has set up a Working Group in the Planning Commission to make DRR efforts more efficient in the next Twelfth Five Year Plan (2012-2017). But the road ahead lies in the words of Ralph Waldo Emerson *"An ounce of action is worth a ton of theory"*.

REFERENCES

Arya, Anand S. and Gupta Trijugi N. [2012]. "Report on Mainstreaming Disaster Risk Reduction in Housing Sector" for National Institute of Disaster Management.

Building Materials & Technology Promotion Council, Government of India. [2002-03] [2003-04]. "Annual Reports".

Building Materials & Technology Promotion Council, Government of India. [2006]. "Vulnerability Atlas of India – 2nd Edition".

Building Materials & Technology Promotion Council, Government of India. [1996-2010]. A number of Pamphlets, Brochures, Manuals, Guidelines, etc.

International Strategy for Disaster Reduction, [2008]. "Indigenous Knowledge for Disaster Risk Reduction – Good Practices and Lessons Learned", Regional Program Officer, UNISDR Asia and Pacific.

Ministry of Agriculture, Government of India [1999]. "IDNDR – Indian Experiences and Initiatives"

Ministry of Home Affairs, Government of India [2012]. "Disaster Management in India", published under the GOI-UNDP Disaster Risk Reduction Programme (2009-2012).

Murthy, C.V.R. [2002-2005]. "IITK-BMTPC Earthquake Tips".

National Disaster Management Authority [2009], "National Policy on Disaster Management – 2009".

National Disaster Management Authority, [2007]. Management of Earthquakes – NDM Guidelines".

ProVention Consortium [2007], "Tools for Mainstreaming".

Report of High Powered Committee [2001], "Disaster Management", Ministry of Agriculture, Government of India.